Neural network for classification of water samples of Shatt Al Arab River

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Abstract: In this study, we developed an automated system that uses a collection of attributes to classify water samples from the Shatt al Arab River (EC, Cl, Ca, Mg, Na, and SO_4). The water categorization system was involved three steps: first, water samples were collected (monthly) from eight locations along the Shatt Al-Arab River in Basra from October 2009 to September 2020. Second, using established procedures measured and analyzed chemical elements such as electrical conductivity (Ec), chloride (Cl), calcium (Ca), magnesium (Mg), sodium (Na), and Sulphate (SO_4). Finally, neural networks with three hidden layers were used for training and testing purposes. The Project was designed by Matlab. The experimental results on the collected database showed that the proposed approach achieves high accuracy in automatic water classification (normal and abnormal).

Keywords: Neural network, Classification, Shatt Al Arab River**.**

1. Introduction

In recent years, Shatt al-Arab has suffered from the problem of pollution caused by the dumping of industrial, agricultural and household wastes directly affecting its quality and use. The most prominent of these pollutants are hydrocarbons, pesticides and heavy metals [1,2]. Several factors have contributed to the deterioration of the water quality of the Shatt al- Arab and its tributaries, including the construction of dams in the upstream countries[3]. the closure of the Karun and Karakha rivers [4]. Water Resources in the Southern Region, Solid Waste and Industrial Liquid, Insecticides and Residues of Massacres, and Fertilizers [5]. The most important results of the pollution of the Shatt al-Arab water led to an environmental disaster suffered by the southern region has been affected by large areas of palm groves, the spread of many diseases, serious epidemics and low productivity of agricultural soils [2]. The water of Shatt Al-Arab River is essential for a variety of uses, including drinking, irrigation, and as a habitat for a variety of creatures. Most rivers and streams have become tourist's destinations and activities due to their scenic qualities [6]. Surface water is generally used as the primary source of water for the provision of potable water in most nations across the world following necessary treatment. When high-quality water is used as a source, treatment costs for potable water production are considerably reduced [7]. As a result, freshwater sources such as rivers and streams must be preserved from contamination, not only for human benefit but also to minimize environmental degradation and biodiversity loss.

Water quality refers to the chemical, physical, and biological characteristics of water, as well as an assessment of its state in relation to human needs [8]. It is used in conjunction with a set of standards that can be used to measure compliance. The accepted standards for assessing water quality are concerned with ecosystem health and the safety of human usage [9]. It is possible to evaluate compliance. Water classification system will be very helpful in many applications. For example, water classification can improve irrigation systems, drinking, drinking water, Industry, and breeding living things. , etc.

There has been no clear systematic assessment of irrigation water quality in Iraq during the previous century. However, the department of environmental survey and the Directorate of water resources in Basra governorate began measuring some of water parameters from January 2007 to December 2012 for different sites of the Shatt Al-Arab river. Previous studies used traditional methods in the process of forecasting and determining the solid components of water [17] and sometimes modern methods are used, however, the percentages of achievement are few [18]. In this study, a modern prediction method based on artificial neural networks, was used to predict the solid components in the waters of the Shatt al-Arab River from the period 2009-2021, where samples were collected from eight regions along the Shatt Al-Arab River (EC, Cl, Ca, Mg, Na, and SO_4) and its classification using a neural network.

2. Methodology

2.1. City description

The confluence of Tigris and Euphrates Rivers at the town of Qurna north of Basra City from the Shatt al Arab River. The Shatt al Arab has a length of 200 Km and a width averag between 400m in Basra City. Eight stations Qurna, Tubular Bridge, Al Muzairah (station1), Saad Birdge(station2),Al k-arma (station3), Alsandbad (station4),Al-Ashar (station5), Abo AlKasseb (station6), Al-Seba (station7),and Al-Foa (station8) were Selected along the river axis in order to investigate water quality trends as shown in figure 2.

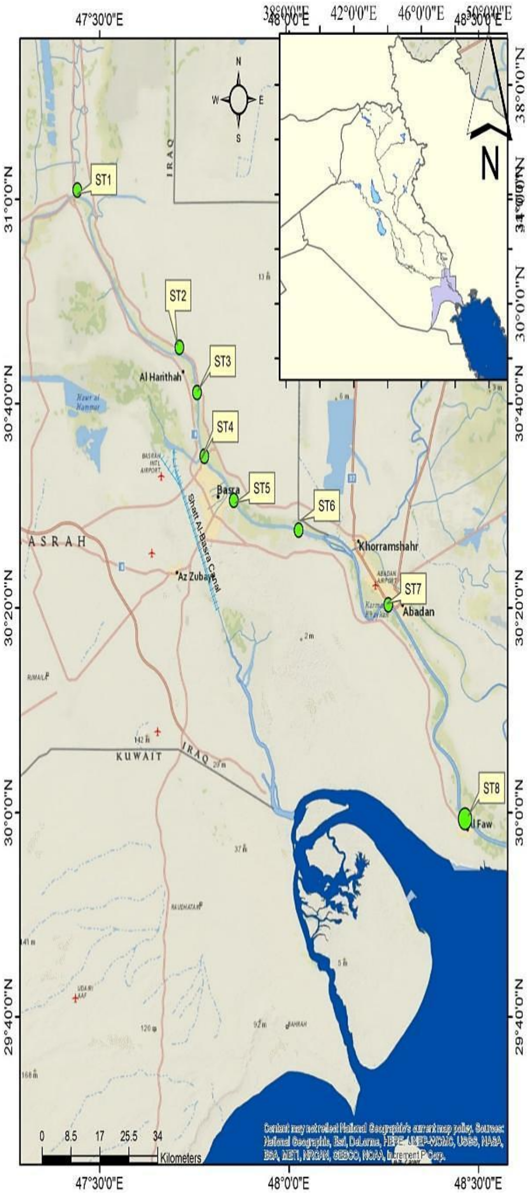

Fig. (2): Map of the sampling locations showing the Shatt Arab River 2009-2021.

2.2.THE PROPOSED SYSTEM

This section gives a general view of the proposed system for water classification. The structure of the proposed system is shown in Figure (1).

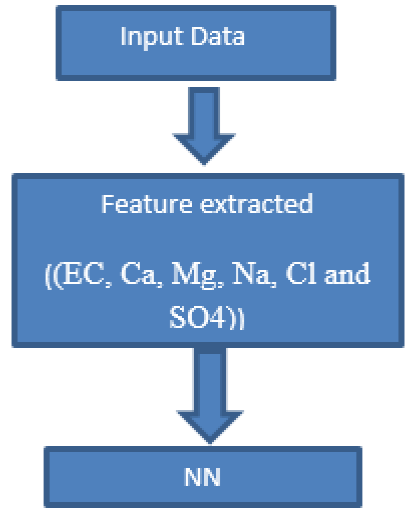

Fig. (1): the essential steps of the proposed system.

The proposed water classification system could be divided into the following three steps:

1-collected data

2-feature extracted

3-water classification

2.2.1. Data and feature extracted

From October 2009 to September 2020, water samples were taken monthly from eight locations along the Shatt Al-Arab River in Basra (Figure 2). Qurna, Tubular Bridge, Al Muzairah (station 1), Saad Birdge (station 2), Al-Karma (station 3), Al-Sandbad (station 4), Al-Ashar (station 5), Abo Al-Kasseb (station 6), Al-Seba (station 7), and Al-Foa (station 8). Water samples were taken from the river's surface in the middle. The cations and anions (Ca, Mg, Na, Cl, and SO_4) were investigated using standard procedures (APHA 1992). A flame photometer was used to determine sodium levels (JENWAY PEP7). 0.01N Na2EDTA was used to titrate calcium. Sulphate was evaluated using a turbidity technique spectrophotometer (CEIL292) and chloride was assessed by titration with 0.01N AgNO3.

2.2.2 Water classification

The final step in the proposed system is water classification, which distinguishes between normal and abnormal samples. After obtaining feature vectors (EC, Cl, Ca, Mg, Na, and SO_4) and storing them in a mat file, the classification step is performed. In our approach, we used neural network (NN) as a classification method, all those steps can be described as following:

Step 1: Creating a feed forward neural network with three hidden layers and 150,150,150 neurons in each hidden layer. The properties of the inputs decide the input layer for the generated neural network. This net takes a feature vector as input, and we have six-attribute feature vector. As a result, the number of neurons in the input layer is six, whereas the number of neurons in the output layer is controlled by the number of classes. Because there are two classes (normal and abnormal), the number of neurons in the output layer is two.

Step 2: identifying the critical parameter, learning rate equal to one, epochs equal to 20000, maximum number of iterations, training time infinity, data division function (divide rand), transfer function of ith layer hyperbolic tangent sigmoid transfer function is used 'tansig', linear activation function is selected for output layer 'purelin', performance function, default = 'mse 'and training function is back propagation function (Scaled conjugate gradient), weight and bias is generating randomly.

Step 3: Using train data to train the network and target matrix (target matrix is matrix with two rows and sixty columns each row consists of a vector of all zero values except for a 1 in element i, where i is the class they are to represent).

Step 4: Taking the initialized neural network and simulates it with network input matrix (train data), return the indices to the largest output as class predict.

Step 5: Calculating the network performance; the outcome is the net's total accuracy.

Step 6: Using the training net and test data, simulating the neural network and returning the indices to the greatest output as class predict.

3. Results and Discussion

In this paper, MATLAB environment was used to implement the proposed method, on HP laptop Core i7 processor with the RAM of 12GB. We used data obtained from eight sites along the Shatt Al-Arab River in Basra city from October 2009 to September 2020 to test the suggested technique. Extracted features for them and stored in data base with size 32*6, where 32 refer to the number of sequence to eight sites and 6 refer to the number of features in features vector. We used cross validation (holdout) [15, 20, 16], cross validation is a data resampling method to assess `the generalization ability of predictive models and to prevent overfitting, it used to divide the database to train set and test set, the best sequence to test phase and the remain for training phase (twenty four sequences used to training NN classifier and test with one sequence). The total accuracy from the NN, it equal to the ratio between the correct predict class label on all sample that test.

$$\text{Total Accuracy} = \frac{\text{correct predict class label}}{\text{all sample that test}} \times 100\% \quad (1)[12]$$

The network gives high accuracy when train and test equal to 98% with simple training time equal to (0.19 seconds) at 30 epochs, with best training performance is 3.082e-08 at epoch 30, as shown in figure (3). While figure (4) illustrates the view of our network and figure (5) illustrates the snapshot generated during the training neural network using back propagation algorithm.

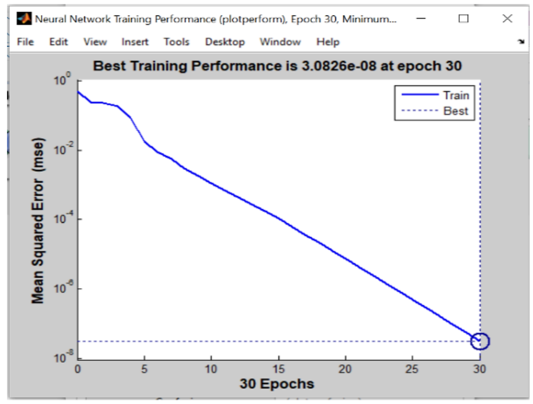

Fig. (3): Neural network training performance at 30 epochs.

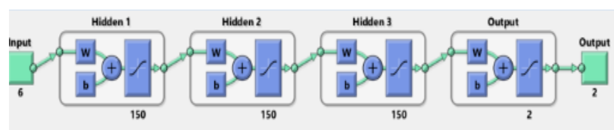

Fig. (4): View of neural network.

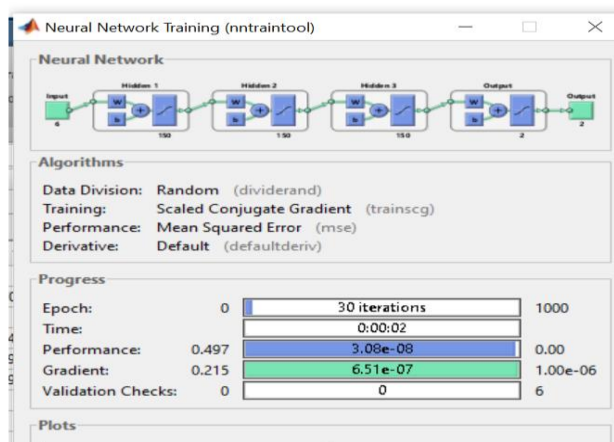

Fig. (5): Neural network training.

It is noticed from Table (1) that the lowest value of electrical conductivity (EC) appears in the northern stations in the upstream and

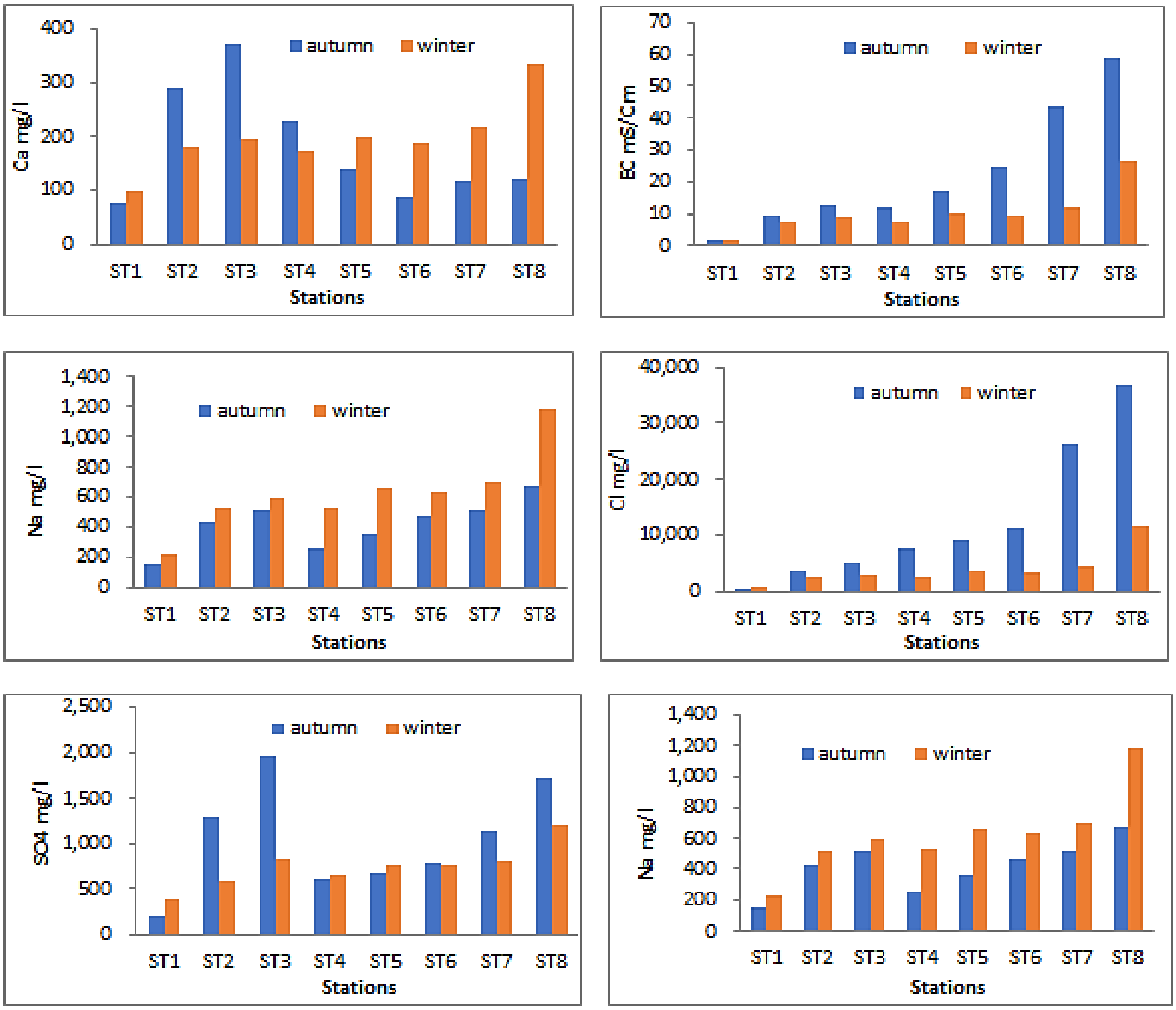

Fig. (6): Distributions of Ca ,EC, Na, Cl, SO4, and Mg parameters in selection stations of Shatt AL-Arab River during autumn and winter.

gradually rises in the direction of the south there is a sharp increase in ST7 and ST8 in the areas which close to the sea, The minimum and maximum E.C values in this study are reached 1.40 to 60.55 dS/cm with mean ranged from 1.64 ±0.32 to 42.57±25.04 appeared in ST1 and ST 8, respectively. So that Shatt AL-Arab is considered as a saline water comparison with other rivers in the world [10]. This wide range of variation resulted from decreasing of water

towards the bottom of the river discharge to the Shatt Al-Arab River from major sources of the Euphrates and Tigris Rivers, which had significant declines in their discharge as a result of dam constructions in upstream countries [2-4]. The dominant anions were Chloride ranged from 465.45 to 38695 mg/l with a general average 8205.28 ±10065.16. This high value of standard deviation was due to high dispersion values. While the dominant cations was Na (55.08- 1574.04) mg/l and the total mean was 525.48±335.61 mg/l.

Table (1): The Mean, standard deviation, Minimum and Maximum value of and i Mg, Na, Cl and SO4 in study stations.

Stations	Statistics	EC	Cl	Ca	Mg	Na	SO4
		mS/cm	Mg/l				
ST1	Mean	1.64	564.55	87.5	88.39	185.41	290.28
	Std. Deviation	0.32	125.61	19.49	30.7	82.93	167.78
	Minimum	1.4	465.45	72	54.68	69.19	61.84
	Maximum	2.12	745.5	116	123.93	260.09	461.84
ST2	Mean	8.48	3121.01	235.5	291.9	476.6	945.09
	Std. Deviation	4.28	1528.87	81.75	164.82	174.76	490.06
	Minimum	2.91	1047.25	168	82.62	320.86	412.73
	Maximum	12.09	4413.75	352	483.57	720.43	1579.46
ST3	Mean	10.7	4072.56	283	380.9	555.53	1393.91
	Std. Deviation	3.59	1655	112.49	143.86	104.93	658.44
	Minimum	5.43	1757.25	148	225.99	480.17	793.35
	Maximum	13.49	5483.75	404	534.6	708.32	1993.95
ST4	Mean	9.79	5071.19	200	281.27	392.62	635.38
	Std. Deviation	5.36	3905.77	54.26	133.16	280.59	153.05
	Minimum	2.59	869.75	120	136.08	55.08	474.28
	Maximum	14.83	10295	240	437.4	732.53	837.82
ST5	Mean	13.64	6241.25	170	400.95	509.66	721.46
	Std. Deviation	6.72	4520.28	68.31	196.16	302.57	115.67
	Minimum	4.7	1562	80	182.25	140.4	636.52
	Maximum	20.75	12425	240	656.1	871.78	892.34
ST6	Mean	17.09	7162.63	139	357.21	550.49	771.81
	Std. Deviation	9.18	5259.41	59.27	116.79	255.83	84.19
	Minimum	7.45	2343	80	216.27	186.75	666.96
	Maximum	27.45	14200	192	456.84	752.75	845.15
ST7	Mean	27.7	15281.69	167	448.34	605.97	971.21
	Std. Deviation	19.12	12927.6	63.86	335.21	297.37	230.89
	Minimum	5.28	1757.25	112	145.8	253.92	641.39
	Maximum	46.4	26980	248	911.25	920.21	1136.03
ST8	Mean	42.57	24127.38	228	781.25	927.6	1465.95
	Std. Deviation	25.04	15865.85	154.95	551.95	619.53	500.22
	Minimum	6.06	4047	88	306.18	128.3	745.22
	Maximum	60.55	38695	444	1372.95	1574.04	1890.94

Shatt Al-Arab is classified as marine waters indicating that sodium chloride salt is the dominant salt. The order of ions is Ca-Mg-Sodium -SO4 Chloride at all stations, according to Hem (1992) the sea water cations and anions can be is order as: Na > Mg > Ca, and Cl> SO4 > CO3. However, in fresh water is order as the following: Ca > Na >Mg, CO3>SO4 > Cl. These results are consistent with the literatures [2,3,4, 11] and showed that the water of the Shatt Al-Arab River are similar to marine water, thus giving a clear indication of the impact of the Arabian Gulf's saline water on that river. The same behavior was observed in the autumn compared with winter season for each of the elements EC, Mg, SO_4 and Cl values (Fig.6). They were also rising upstream towards the sea, while both sodium and calcium ions showed a high concentration during the winter but they were also rising towards the downstream. These result can be agree with some studies that showed variation of the parameters were monitored during different seasons in Shatt Al Arab River [11-13]

4. Conclusion

Neural networks with three hidden layers (150,150,150) were used for training and testing purposes with learning rate equal to one, epochs equal to 20000. The experimental results on the collected database showed that the proposed approach achieves high accuracy in automatic water classification. The network gave high accuracy when train and test were equal to 98% with simple training time equal to (0.19 seconds) at 30 epochs, with best training performance is 3.082e-08 at epoch 30.

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